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Thursday May 5th, 2011

Donald Cripps
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Dr. Cripps,

Included is our final documentation for our senior project. This project has given us a significant understanding into the work that is involved in developing a product for the commercial market. The document includes our initial idea, the decisions we made, the development of our product, as well as suggestions or changes we would like to implement in our design if we were not under a time constraint. Overall we are pleased with the end result, and we are sure you will be as well. We appreciate your helpful insight and encouragement as we researched, developed, and implemented this project.

Sincerely,

Daniel Kunz
Jared Jeppsen
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Senior Project: Final Report

Small Business Security

ECE 4840/4850
May 5th, 2011

Daniel Kunz, Jared Jeppsen Michael Engh, Curtis Ostrander

Instructor Approval _____ _____

Dr. Donald Cripps Date
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Abstract

The purpose of this project is to design an economical and efficient method of supplying security to small business operators and owners. The design of this system is to be modular for ease of expansion and upgradeability. The economic advantage of such a system would be the lessening or removal of a monthly fee paid to a security contractor. All costs would be incurred up front or at the time of expansion or upgrade.

Table of Contents

Abstract iii
Table of Contents iv
List of Tables vi
Table of Figures vii
Acknowledgements viii
1.0 Introduction 1
1.1 Problem Statement and Design Objectives 1
1.2 Summary of Design Process You Executed 2
1.3 Summary of Final Results 2
1.4 Organization and Summary of Report 2
2.0 Conceptual Review and Preliminary Design 3
2.1 Problem Analysis 3
2.1.1 Review of Problem 3
2.1.2 Summary of Specifications 4
2.1.3 Technical Approach 4
2.1.3.1 Basic Design Concept 4
2.1.3.2 Access and Perimeter Solutions 5
2.1.3.3 Control Solutions 7
2.2 Decision Analysis 7
2.2.1 Access Module Decision Process 8
2.2.2 Perimeter Module Decision Process 9
3.0 Basic Solution Description 10
3.1 Schematics and flow sheets 12
4.0 Design of System Components 16
4.1 Description of Components/Specs 16
4.2 Discussion of Design Detail 17
4.3 Fabrication, Construction, or Production Instructions/Specs. 26
4.4 Summary of Final Design Results 27
5.0 Project Implementation and Operation 28
5.1 Details of Implementation 28
5.2 Operational Test Results 29
5.3 What Improvements are Suggested by the Design Results 30
6.0 Final Scope of Work Statement 31
6.1 Summary of Completed Work 31
6.2 Summary of Additional Work 31
6.3 Lessons learned 31
6.4 Related project management issues 32
7.0 Other Issues 33
7.1 Material Selection 33
7.3 Safety 33
7.4 Societal Impact 33
7.5 Maintenance 34
7.6 Contracts and Other Legal/Ethical Issues 34

7.7 Customer Support and Training 34
7.8 Product Documentation 35
8.0 Cost Estimations 36
8.1 Estimate of System Costs 36
8.2 Estimate of Design Cost 37
9.0 Project Management Summary 38
9.1 Time: Activities, Duration, and Order 38
10.0 Conclusion 40
Appendix A – Canakit UK1104 Specifications 41
Appendix B – Phidget RFID Specifications 42
Appendix C – SECO-LARM SK-990AQ Specifications 43

List of Tables

Table 1 - Part Suppliers 33
Table 2 - Project Cost 36

Table of Figures

Figure 1 - System Block Diagram 12
Figure 2 - Monitoring Block Diagram 13
Figure 3 - Door Access Block Diagram 14
Figure 4 - GUI Interface Flow Chart 15
Figure 5 - Schematic Diagram for Door Access 18
Figure 6 - Detailed System Block Diagram 19
Figure 7 - Main GUI Screen 20
Figure 8 - GUI Security Notification Settings Screen 22
Figure 9 - GUI Security Badge Management Screen 23
Figure 10 - GUI Surveillance Screen 24
Figure 11 - GUI Log View Screen 25
Figure 12 - Gantt Chart 38

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1.0 Introduction

With the continuing uncertainties of the current economy, the need for a security system designed around a small business is essential. Our aim is to develop a system that is completely internal and controlled entirely by the business owner, rather than an outside monitoring company. This would help reduce costs dramatically by eliminating the need of a monthly security subscription fee.

1.1 Problem Statement and Design Objectives

Many small retail businesses would benefit greatly from a security system that is cost effective, user friendly, and expandable. The design of this system is centered on a three level structure: low, medium, and high. Low level access will be granted by a radio frequency (RF) badge scanner. Medium level access will also be granted by an RF scanner and will have a camera that takes a picture of the person attempting to access the area. High level access will be granted by an RF scanner, a numerical code, and also have a camera that will take a picture of the person accessing the area.

Because of the modular approach, components, such as the camera, numerical keypad, electromagnetic locks, and door alarm sensors, can easily be added or taken away from any door according to the need and desire of the business owner.

To make the system easy to use, a graphical user interface (GUI) will be created that gives all the control to the business owner. The GUI will allow the

user to program employee badges with their applicable numeric codes and also assign security clearance levels.

1.2 Summary of Design Process You Executed

We began our design by weighing the pros and cons of different security system components. After researching the different options, we chose to execute the design using components that were compatible with the universal serial bus (USB). Our research also showed that writing software that would access several devices simultaneously would be the best option.

1.3 Summary of Final Results

Final results show that coding for the individual components was indeed simple. The only component that proved to be overly difficult was the camera. This is because only one camera could be accessed at a time. A GUI has been created that grants control of the system to the business owner.

1.4 Organization and Summary of Report

The purpose of this document is to review the overall design, design solutions, performance optimization, project implementation, the final result, and any other issues that arose while doing this project.

2.0 Conceptual Review and Preliminary Design

Design considerations will be covered in two major sections, an analysis of the problem and a design analysis.

2.1 Problem Analysis

The analysis of the problem will be covered in the following sections: a review of the problem; a summary of the specifications; and a technical approach.

2.1.1 Review of Problem

The design criteria will be to create a security system which will be economic, easy to operate, and easy to upgrade or expand.

The economic considerations are the cost of initial installation and any upgrades or expansions to the system. Unique to this design will be the removal of any costs associated with monthly fees paid to a security contracting service.

To create a user-friendly design, the system will have a Graphical User Interface (GUI) to operate the system once installed. The GUI will allow the operator to enter or modify a security badge, allow access to any cameras, and alert the monitoring security personnel via text messaging and e-mail in the event of a security issue. Alerting any emergency personnel, such as the police or fire department, shall be the responsibility of the customer or his delegates.

Upgrading or expansion of the system can occur easily due to a modular design. Modules will consist of a range of either entry modules or perimeter

modules. Entry modules can be configured according to the security control desired such as basic, intermediate, or advanced security. Perimeter modules can consist of window modules, interior or exterior surveillance cameras, and even parking lot access gates.

2.1.2 Summary of Specifications

A summary of the design specifications are as follows:

- Low cost
- Modular Design
- User-Friendly
- Easy to Upgrade or Expand

2.1.3 Technical Approach

The technical approach to our design will be discussed in the following sections; the basic design concept, access and perimeter solutions, and control solutions.

2.1.3.1 Basic Design Concept

The concept of this design is one which uses a central computer utilizing an event driven security program operating with a GUI. An event can be raised by a given access module such as an access request or an unauthorized access (I.E. Opening of a door without using a security point). Additionally the perimeter security modules can trigger an event by detection of a fire, loss of power, or unauthorized access of a window or roof hatch.

In the event of a security issue, the security program will set a visual and audible alarm and send an emergency notification message via text messaging and/or e-mail to each person in the notification list.

2.1.3.2 Access and Perimeter Solutions

Possible access solutions available for use are numerous. The following list shows access methodologies available:

- Keypad and/or Cipher Locks
- Magnetic Strip Readers
- Proximity Badge Readers
- Fingerprint Readers
- Retinal Scanners

Each of these solutions contains their own unique advantages and disadvantages. An examination of each possible access solution is made with our design criteria in mind.

Keypad and cipher lock solutions have the advantage of being low cost to implement, but have many disadvantages. The disadvantages of this solution are the difficulty in monitoring access, detecting the number of attempts to access, and the ease in breaking the access code. Additionally, it relies on the ability of the user to remember their access code.

Magnetic strip readers provide several advantages, those being the low cost of readers, the magnetic strip can be implemented on an employee badge, and the ability to monitor and grant access from a controlling device (computer). The disadvantages are not numerous, but are important. These disadvantages

are: wear on the magnetic strip with multiple reads; possible demagnetization of the magnetic strip from outside influences; and a technology level that is being phased out in most businesses.

Proximity badge readers are a bit more expensive, but not excessively so. They offer the advantages of being incorporated into an employee badge or key fob, are not susceptible to wear, and are widely used in business today. The proximity badge is not without disadvantages. The main disadvantage is the ability for the proximity badge code to be read by an “eavesdropping” RF reader. Another disadvantage is the need to carry an additional badge or fob if it is not incorporated into the employee badge.

Fingerprint readers have the advantage of being very secure as an individual’s fingerprint is unique. The disadvantages are: high cost, difficult to incorporate from a programming standpoint, and the inability to read an individual’s fingerprint under dry skin conditions.

Retinal scanners are much like fingerprint readers in the aspect of being very secure due to the unique signature of an individual’s retina. However, the disadvantages are weighty. They are: very high cost, technology still in the experimental stages, and difficulty in programming retinal image recognition.

Perimeter solutions are methods in determining the state of a door, methods in viewing the interior or exterior of the building, and detection methods for a fire or loss of power. The simplest method for determining the state of a door is by the use of a limit switch. Methods to view the interior or exterior of a building will be determined by the functionality of the GUI interface.

There are two possible solutions available, USB or IP (Internet Protocol) cameras. Detection methods for a fire or loss of power can be done using commercial fire detectors and power monitoring devices.

2.1.3.3 Control Solutions

Control Solutions are the methods to be used to communicate with the individual access and perimeter modules. There are two methods to consider, that of a USB driven system or an IP Ethernet based system. Each method will use a Graphical User Interface based program to react to events raised by the individual access or perimeter module.

The USB system would use the common USB 2.0 communication port of the controlling computer to communicate with one or more modules. Each module will use a USB relay board to communicate with the controlling program. USB hubs will be used to allow multiple modules, and USB extenders or repeaters will be used to increase the distance between the controlling computer and the individual module.

The Ethernet system would use IP addressing to communicate to each module. Each module will be a microprocessor based solution that will communicate to the controlling computer via Ethernet IP protocols. In effect, this solution will be a distributed network system connecting the controlling computer to the individual access or perimeter modules.

2.2 Decision Analysis

Based upon the direction the project team wanted to go and with the limited budget the team had, it was decided to use a USB based system. These parts were readily available for a reasonable price, and most of the USB devices came with drivers for a windows based solution.

Additionally, the criteria requirements for our design helped us to determine what solutions to arrive at for the access modules and what our deliverables were to be. The decision process for the access modules is discussed in section 2.2.1 of this document. The decision process for the perimeter modules is discussed in section 2.2.2 of this document.

2.2.1 Access Module Decision Process

The decision for the access module requirements is based upon the criteria of cost effectiveness and ease of integration into a complete system. With the decision made to pursue a USB format control system, the following modules were selected.

The main component of the access module was the device being used to read the access badge. Due to cost constraints the retinal scanner and the fingerprint reader were discarded immediately. The keypad and cipher lock options did not lend themselves to the overall design of our system in the fact there was no easy method of monitoring by the controlling computer as to when these devices were accessed. This left the magnetic strip and proximity badge readers for consideration.

After weighing the advantages and disadvantages of each, the decision was made to use the proximity badge reader for our design. Proximity badge readers have a variety of interface selections with a USB format being one of them. This type of proximity badge was selected for our design.

2.2.2 Perimeter Module Decision Process

For perimeter modules, a USB format webcam was selected for perimeter cameras and a USB relay board was selected for the communication pathway between the access module and control computer.

3.0 Basic Solution Description

As outlined above, the purpose of this project was to create a security system that would be independent of a security company. This would allow the owner of the business to have more control over the monthly financial costs of the security system. Since this was going to be a security system controlled by the business owner, we decided to use the PC (Personal Computer) as the control center for the security system. Since the PC is a common tool available to nearly every business owner, it would allow us to keep the costs down.

Since we decided to use the PC as the center of the security system, we chose to use the USB (Universal Serial Port) to interface with the peripherals for the security system. Although this technology is not new by computer standards, it has proven itself to be a viable communication medium due to its widespread usage which has resulted in the USB being an industry standard in PCs. However, one of the drawbacks that we had to investigate before we could proceed was a distance limitation with the interface. USB cables have an effective range of about 15 feet. This raised significant problems as the components the computer would need to communicate with would be three to four times this distance. We spent time researching the problem, and we were able to overcome this issue by using a USB Ethernet extender. This extender allows the USB signal to be broadcasted over the Ethernet cables within the building. This extends the distance to approximately 200 feet.

Once we had been able to resolve the distance limitation, we started looking for other components that a basic security system would need. We

decided to utilize electromagnetic locks that would be actuated by a USB relay board. The relay board that we chose also had 6 channel inputs that would allow us to monitor the status of each of the doors. We also chose the RFID (Radio Frequency Identification) based on their USB compatibility. Once we had these components, we started looking at USB devices that we could use to increase the security on a door. We decided to implement a keypad and web cameras.

Using these components we designed a GUI (Graphical User Interface) to connect all of these components together. Using the GUI, an employer will be able to view security logs, set up security notifications, program employees and badges, as well as have control over each of the magnetic locks manually. The owner will also be able to access the web cameras to monitor areas of his business.

The design is set up to demonstrate three levels of security. The lowest level of security is just an RFID badge reader. The middle level of security incorporates a badge reader, as well as a web camera that takes a picture of whoever scanned the badge. That image is then stored on the businesses computer. The highest level of security will have an RFID badge reader, and will also require the employee to enter a code into the keypad.

In the event a door is opened without authorization, an audible/visual alarm will sound, and a notification will be sent out via text message and e-mail to the contacts that the business owner has set up in the GUI.

3.1 Schematics and flow sheets

The first thing that we did when starting this project was create a high level block diagram of the components that would be needed to design the security system. The block diagram is outlined in Figure 1.

Figure 1 - System Block Diagram

Using this block diagram, we were able to break the project up into three manageable chunks. The first one that we are going to discuss is the monitoring devices. These devices are peripherals that are attached to the door. These devices will take input from the user, and will pass the information back to the GUI which will determine if the user should have access. Figure 2 is a further breakdown of the Monitoring Devices block.

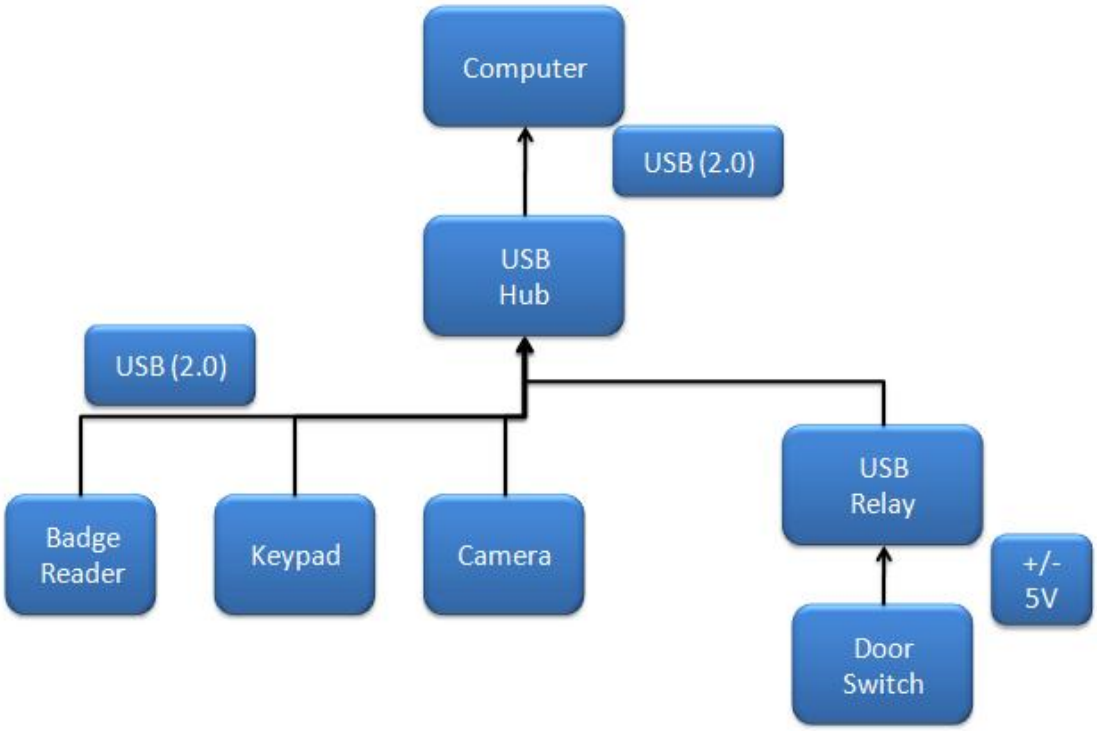


Figure 2 - Monitoring Block Diagram

This block diagram breaks down how each component is connected to the computer. Each of these devices would be connected to a door that needed the additional security. Although the camera, keypad, and badge reader are all mentioned in this block diagram, the user can specify which combination of these devices the door should have. As outlined in the block diagram, each of the connections is through a USB 2.0 connector. Each of the peripherals is connected together at a USB HUB location. Then a USB extender would be used between the USB hub and the computer. Figure 3 is a further breakdown of the devices that will be used to control the access to the door.

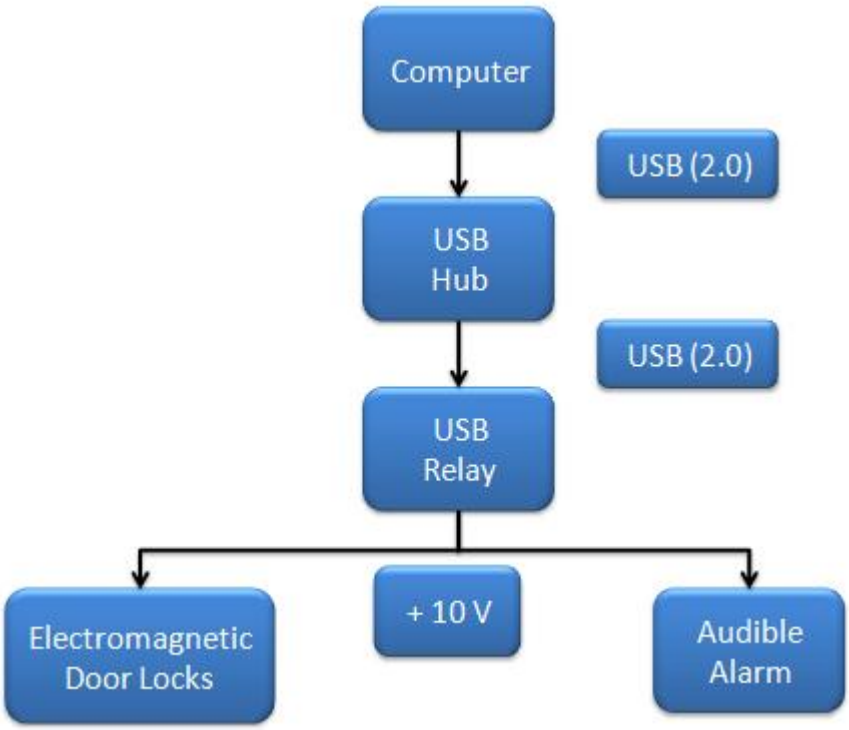


Figure 3 - Door Access Block Diagram

The connection between the computer and the USB relay will be through the USB extender, and USB cables. The USB relay is what will control the actual door access mechanism. When the GUI determines that a valid scan has taken place, the relay is closed, and the electromagnetic lock receives the power. These electromagnetic locks are fail-secure, meaning if they do not have power, they are locked. Once the locks receive power, they release the striker plate and allow the door to be pushed open. Also, if the GUI determines that there is unauthorized access, the relay controlling the alarm will be actuated, and this will sound an audible/visual alarm. Figure 4 is a flow chart for the GUI interface.

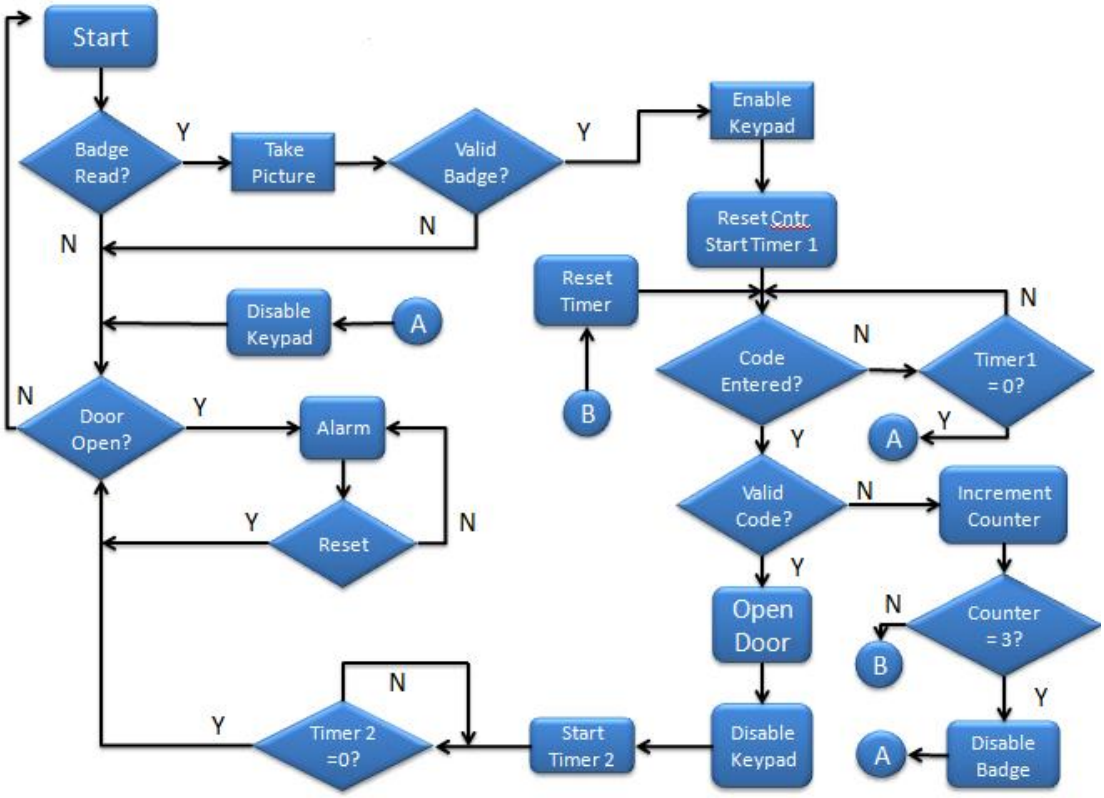


Figure 4 - GUI Interface Flow Chart

The above flow chart explains the functionality of the GUI interface. This flow chart explains the functionality of the peripheral devices and how they interact with the door access mechanisms. This flow chart is an explanation of how the GUI will interact with a high security door that has the badge reader, web camera, and keypad.

4.0 Design of System Components

In this section we will discuss in detail about each of the components used in the security system, as well as the features of the GUI that were developed for the control of the system. We will also discuss the final build information, in addition to the summary of the final design results.

4.1 Description of Components/Specs

In this section, we will give in depth information concerning each of the components that we chose to use for our security system. Although this will not be an all-inclusive list of features, we will mention the ones that are specific to the security system.

Phidgets RDIF Badge Reader – One of the first components that we chose was the RFID badge reader. This badge reader has a USB interface, a 5v relay that can be used to control two LEDs, and libraries that will allow us to write code to interact with the badge readers.

Canakit 4 Relay/6 Channel USB Board – The next component that we had to choose was a relay board that would be used to actuate the electromagnetic locks. This board has four relays. Each of these relays are rated at 5A at 110v which is more than enough for the electromagnetic locks. The board also has a 6 channel input/output interface. Each of the channels can be configured to monitor a 5v source that is also provided by the board. This USB board communicates with the computer through an emulated serial communication port.

iHome Web Cameras – We chose these cameras based on cost, as well as the Megapixels. Each camera is capable of a 5 mega pixel picture and communicates with the computer through the USB 2.0 interface.

Targus 9 Digit Keypad – This is a keypad which has the necessary 9 digit interface, and it communicates through a USB interface.

Dynex 7 port USB hub – This is a 7 port powered USB hub. This hub is intended to increase the connectivity of a single USB port on the controlling computer.

Electromagnetic Door Strikes – These door strikes are used to replace the door strikes in the frame. They are a fail-secure style strike. This means if there is a power failure, the doors will stay secure. The Magnetic locks require 10-14VDC, require 450mA of current, and have an internal resistance of 26 ohms.

Limit switches – This was a switch used to monitor door access. These switches were 5A 120v rated.

Power Supply – The power supply for the locks takes a 100-240V 50/60Hz .6A max input, and outputs 12v at a maximum of 2 amps.

4.2 Discussion of Design Detail

In this section we will review the overall design and schematics for the wiring of the system, as well as a design review of the GUI. Figure 5 below is a schematic of the circuit that describes how the USB relay, power supplies, and electromagnetic locks are connected.

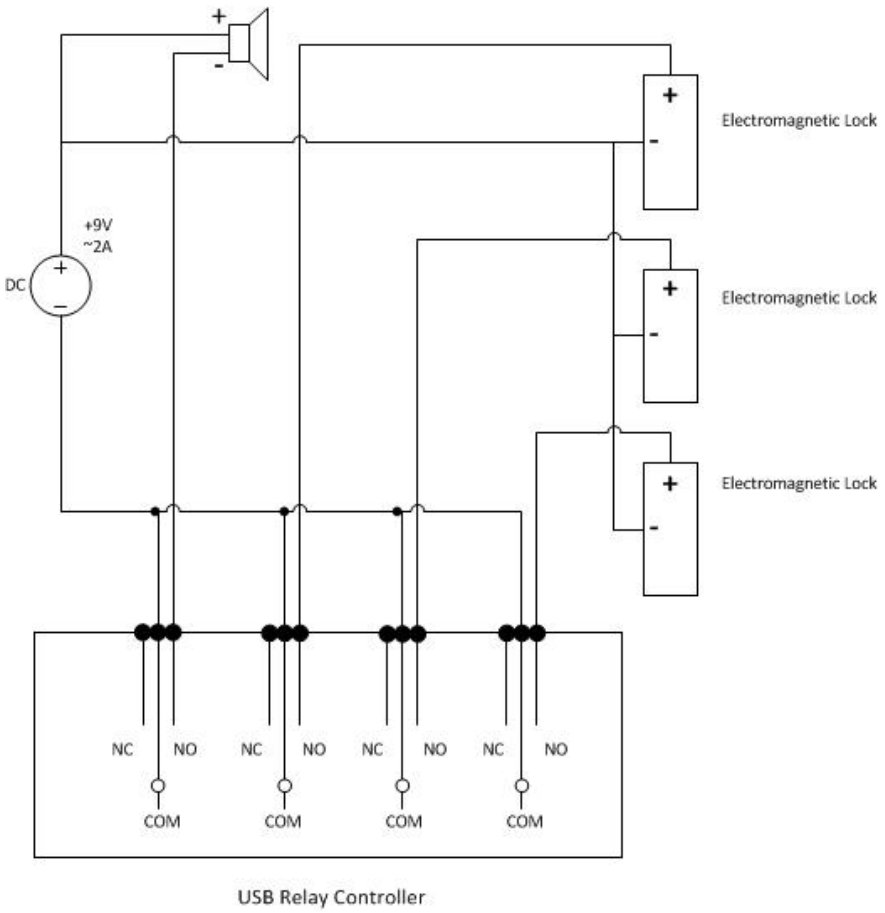


Figure 5 - Schematic Diagram for Door Access

Each of the relays are kept in the normally open position. This means that no current is reaching either the alarms or electromagnetic locks. Once the relay is closed, the circuit is completed, and the alarms and locks will be actuated. The figure below (Figure 6) is a block diagram of how each of the components would be connected to the main computer. The security peripherals (badge reader, keypad, and web camera) all send information about the user back to the GUI, which in turn decides if the user should be allowed to enter. If the GUI determines that the user should have access, a command is sent to the USB relay that will open the electromagnetic lock.

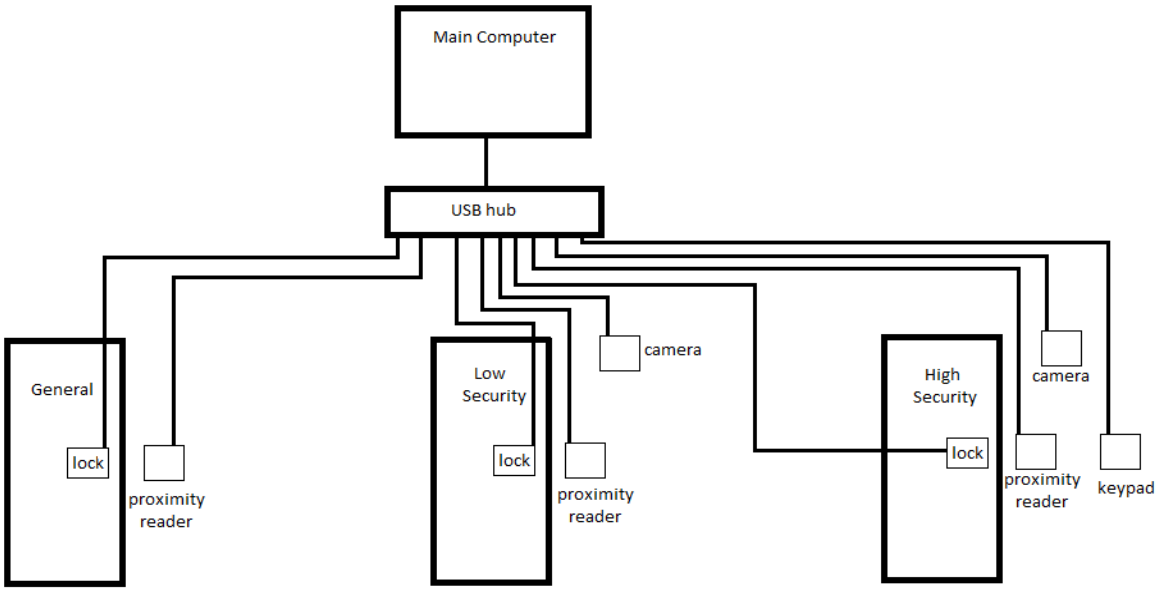


Figure 6 - Detailed System Block Diagram

In the next section, we will be reviewing the different features of the GUI that will be used to control the security periphrials. Figure 7 is the main GUI interface.

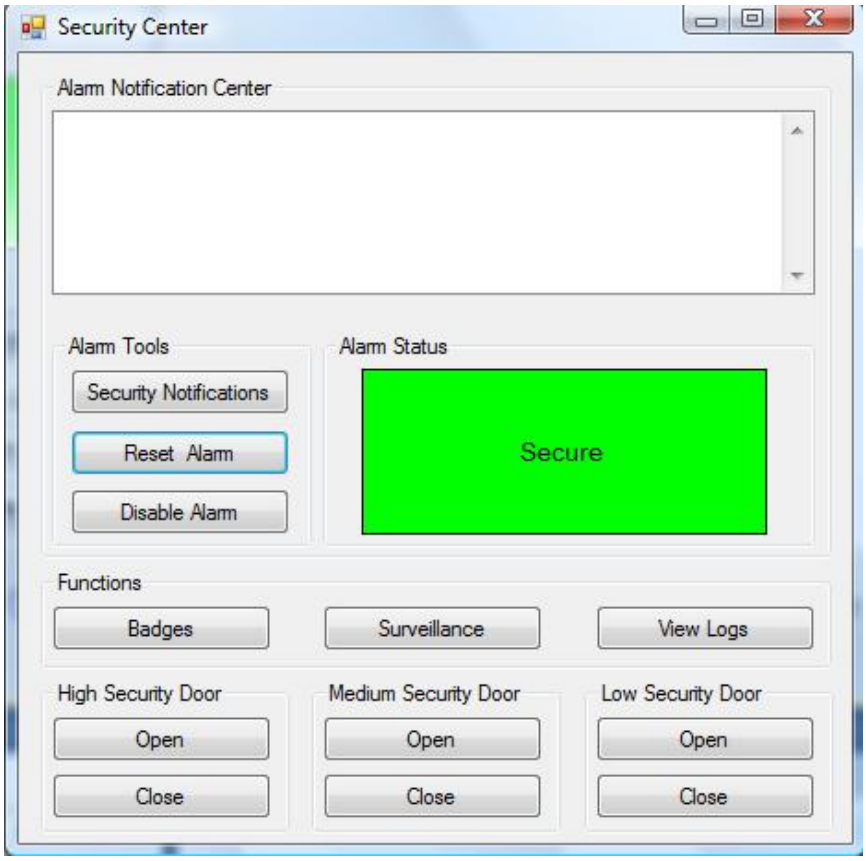


Figure 7 - Main GUI Screen

The first thing the user will notice is the text box at the top of the screen. In this box the notifications will be diplayed for the user to see. The notifications will include invalid badge scans, valid badge scans, and alarm notifications. In addition to displaying this information, the GUI will also save all of this information in a text file. Directly beneath the text box on the left hand side, there are three buttons. Their functions are described below:

Security notifications: This will open up another form that will allow you to set up the security notifications for when the alarm goes off. This will be discusssed in further detail below.

Reset Alarm – When the user clicks on this button, the audible/visual alarm will be turned off, the action will be recorded in the list box, and the GUI will start monitoring the doors for security again.

Disable Alarm – When the user clicks on this button, the GUI will stop monitoring the doors.

Alarm Status Box – The box to the right of these buttons (shown in green above) displays the status of the alarm. When the alarm is working normally, it will display the green box with the text “Secure” in the middle. When the alarm is tripped, the box will alternate between green and red getting the attention of the user. The text will also change in the box from “Secure” to “Alarm!” When the user resets the alarm, this box will go back to green with the “Secure” text. If the user clicks on the “Disable” button, the text will change to “Disabled” and the box will turn gray.

The next part of the GUI are the “Badges”, “Surveillance”, and “View Logs” buttons. Each of these buttons will open up a new window with different functionality that will be outlined further below. The final buttons are manual overrides. If the user clicks on the “Open” Button, the corresponding door relay will remain open until the user clicks on the “Closed” Button. When the user clicks on the “Closed” button, the door will be monitored for access through the GUI as normal. The next section in the GUI (Figure 8 page 22) is where the user will go to set up the security notifications.

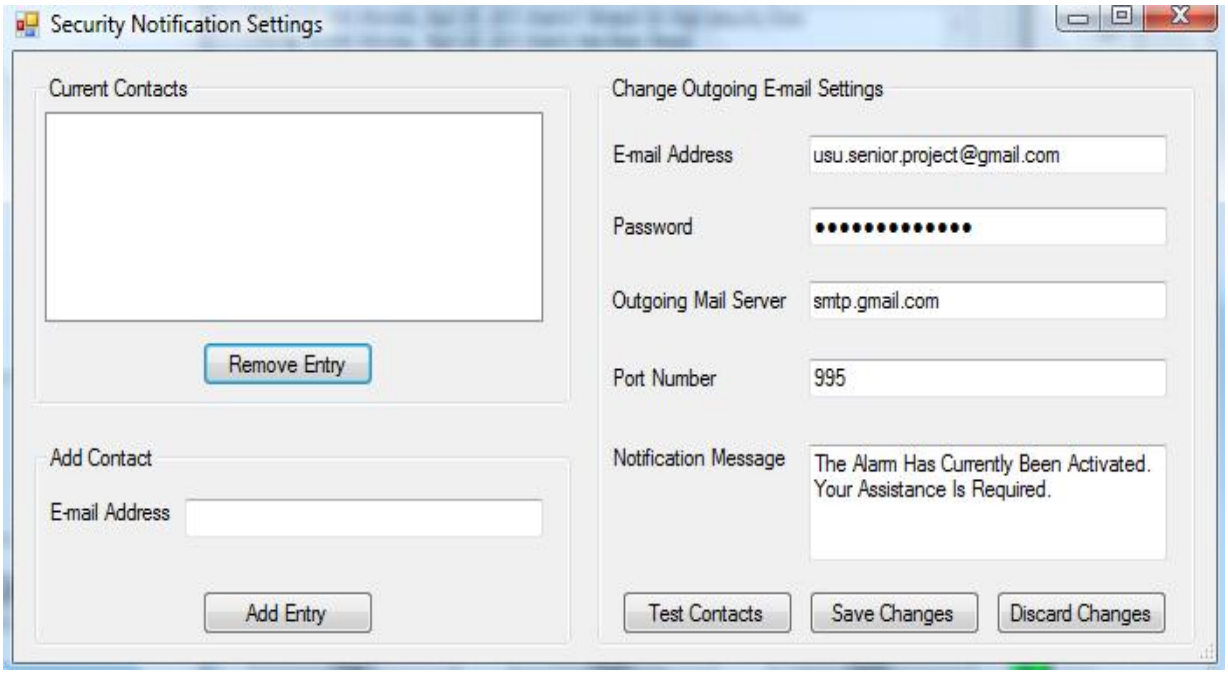


Figure 8 - GUI Security Notification Settings Screen

On the left hand side there is a box that will contain all of the text messages and e-mail addresses that will be notified if there is a security problem. If the user needs to remove a contact from this list, they will need to simply click on the contact, and then click on the “Remove Entry” button. If the user would like to add a contact, they will just need to enter the e-mail address/text message address to the box in the “Add Contact” section and click on the “Add Entry” button. This will add the contact to the list box at the top of the window. On the right hand side the user will need to set up their e-mail address. The program will send out the notifications through the users e-mail address. You will also be able to modify the message that is sent out to the contacts in the text box in the bottom right side of the window. In the bottom of the “Notification Message” box, there are three buttons. One will allow you to send a test message to the contact list, the save changes button will save any

changes that you made to the e-mail settings or notifcation message. The final button “Discard Changes” will allow you to discard any changes that you made to your settings. If you have made changes and click on this button, the changes will be replaced with the last saved settings. The next figure (Figure 9) is the window where the user can control and administer the badges that are programmed in the system.

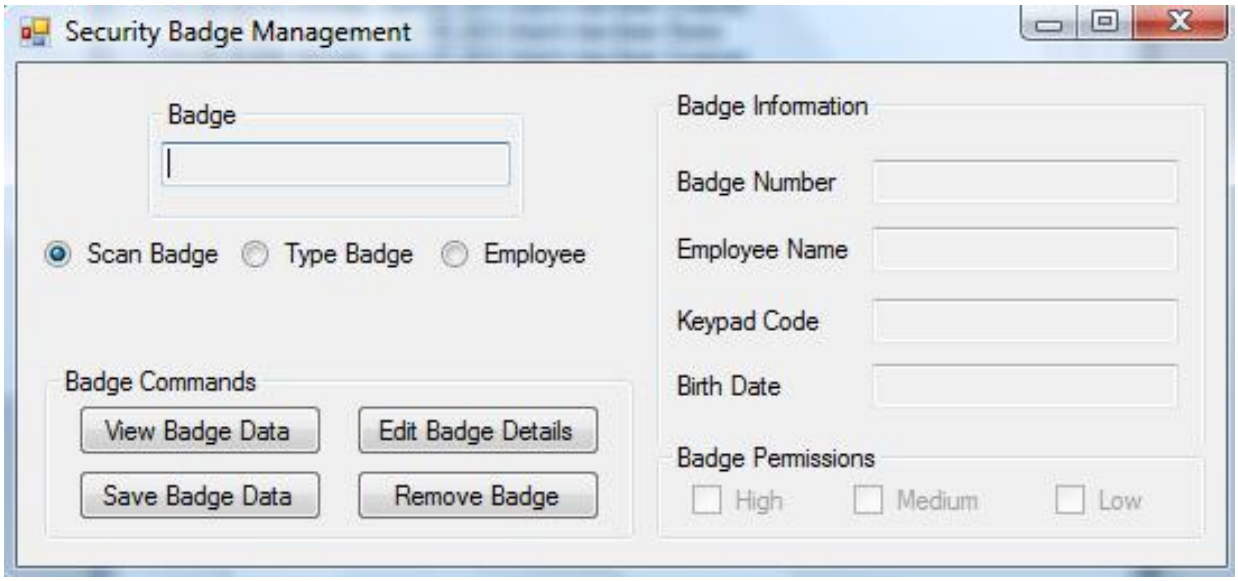


Figure 9 - GUI Security Badge Management Screen

There are three ways to look up an employee or card information. The first will be to simply scan the badge. When the badge is scanned, the RFID number is displayed in the box. The next way is to manually enter the RFID number. The final way is to select the Employee option. When the user selects this option, it will create a drop down list of the names of every employee that is on record. Once a badge is scanned or typed; or an employee is selected from the drop down, the user can then click on the “View Badge Data” button. This will fill the boxes on the right hand side of the screen with the employee data. If

the badge is not currently associated to an employee, the fields will display N/A. If the user would like to make changes to the badge, or to the permissions, they can click on the “Edit Badge Details” Once you have clicked on this button, you will be able to alter all aspects of the details, including what doors the employee should have permission to access. Once any changes are made, the user will need to click on the “Save Badge Data” The information will then be saved and a message box will pop up prompting the user that the information has been saved. Similarly, if the user wants to remove an employee, once the boxes are filled out on the right by clicking on the “View Badge Details” button, they will be able to click on the “Remove Badge” button. This will prompt the user to make sure they want to remove the employee. Once they confirm they want the employee removed, the contents will be removed, and the user will receive a message letting them know the information was successfully removed. The next figure (Figure 10) displays the web camera footage in real time.

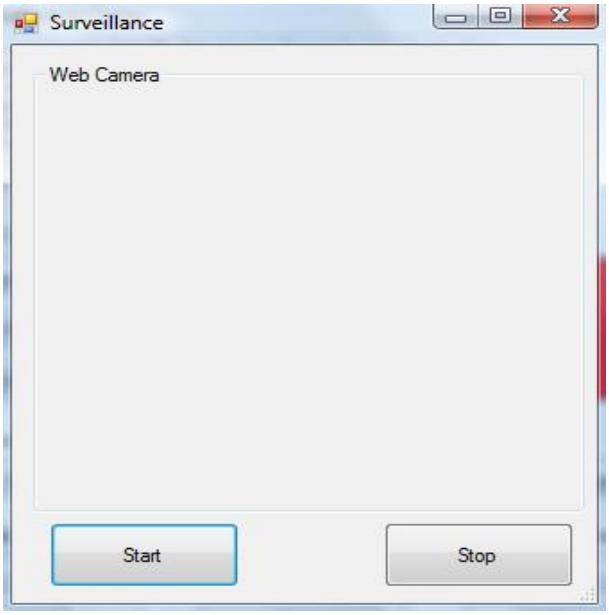


Figure 10 - GUI Surveillance Screen

This will allow the user to monitor the business in real time. If you click on the start button, it will start the stream. This will not happen automatically to reduce the load on the computer. When the user is done looking at the feed, they can either close the window, or select the “Stop” button. The final section of the GUI (Figure 11) is how the user will review the logs.

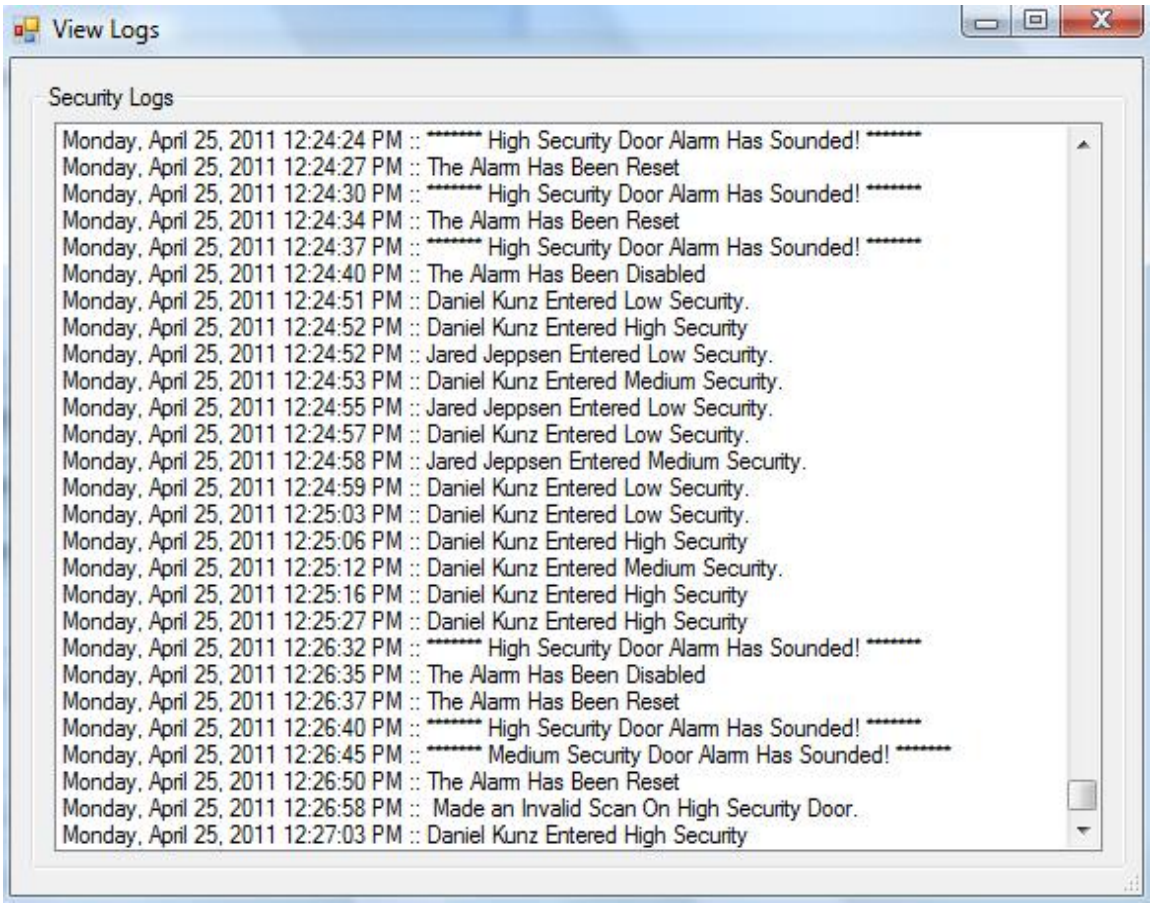

View Logs
Security Logs
Monday, April 25, 2011 12:24:24 PM :: ******* High Security Door Alarm Has Sounded! *******
Monday, April 25, 2011 12:24:27 PM :: The Alarm Has Been Reset
Monday, April 25, 2011 12:24:30 PM :: ******* High Security Door Alarm Has Sounded! *******
Monday, April 25, 2011 12:24:34 PM :: The Alarm Has Been Reset
Monday, April 25, 2011 12:24:37 PM :: ******* High Security Door Alarm Has Sounded! *******
Monday, April 25, 2011 12:24:40 PM :: The Alarm Has Been Disabled
Monday, April 25, 2011 12:24:51 PM :: Daniel Kunz Entered Low Security.
Monday, April 25, 2011 12:24:52 PM :: Daniel Kunz Entered High Security
Monday, April 25, 2011 12:24:52 PM :: Jared Jeppsen Entered Low Security.
Monday, April 25, 2011 12:24:53 PM :: Daniel Kunz Entered Medium Security.
Monday, April 25, 2011 12:24:55 PM :: Jared Jeppsen Entered Low Security.
Monday, April 25, 2011 12:24:57 PM :: Daniel Kunz Entered Low Security.
Monday, April 25, 2011 12:24:58 PM :: Jared Jeppsen Entered Medium Security.
Monday, April 25, 2011 12:24:59 PM :: Daniel Kunz Entered Low Security.
Monday, April 25, 2011 12:25:03 PM :: Daniel Kunz Entered Low Security.
Monday, April 25, 2011 12:25:06 PM :: Daniel Kunz Entered High Security
Monday, April 25, 2011 12:25:12 PM :: Daniel Kunz Entered Medium Security.
Monday, April 25, 2011 12:25:16 PM :: Daniel Kunz Entered High Security
Monday, April 25, 2011 12:25:27 PM :: Daniel Kunz Entered High Security
Monday, April 25, 2011 12:26:32 PM :: ******* High Security Door Alarm Has Sounded! *******
Monday, April 25, 2011 12:26:35 PM :: The Alarm Has Been Disabled
Monday, April 25, 2011 12:26:37 PM :: The Alarm Has Been Reset
Monday, April 25, 2011 12:26:40 PM :: ******* High Security Door Alarm Has Sounded! *******
Monday, April 25, 2011 12:26:45 PM :: ******* Medium Security Door Alarm Has Sounded! *******
Monday, April 25, 2011 12:26:50 PM :: The Alarm Has Been Reset
Monday, April 25, 2011 12:26:58 PM :: Made an Invalid Scan On High Security Door.
Monday, April 25, 2011 12:27:03 PM :: Daniel Kunz Entered High Security

Figure 11 - GUI Log View Screen

The final section of the GUI is the log viewer. This will allow the user to look over the logs since the system was installed. It displays when a badge was scanned, whether it was valid or not, if an alarm was triggered and which

door triggered it, and also if the alarm was reset or disabled. If the user would like to see the associated web cam picture with a particular door that has a web camera installed, they would simply need to double click on the entry in the text box and the image would pull up in a window.

4.3 Fabrication, Construction, or Production Instructions/Specs.

The demo doors that we have were fabricated by Cantwell Bros. Lumber Company. However, due to the fact that they have not been mounted in a wall, we had to come up with a way of standing them up so that when you open a door, they do not fall over. Using some scrap lumber we were able to fabricate stands with support arms that hold the door frames in place and create the stability needed to open the doors. The door jambs all had to be carved out by hand to fit the door strikes and door knobs. This was done using a hammer and chisel. The limit switches that are used for monitoring the doors were placed in the upper corner in such a way that when the door is closed, the switch is actuated.

The 9V power supply was modified to accommodate the amount of grounds needed for the relays and door strikes. All grounds are common through the power supply. The door strikes receive their power via their respective relay. The alarm also receives power from the relay. The limit switches receive their power from the +5V channel pins located on the relay board. The other channel pins monitor each of the switches individually waiting for a signal that the door has been opened. For the demonstration, the RFID

badge readers, camera, and keypad will all be mounted on the top of their respective doors.

4.4 Summary of Final Design Results

In summary we learned quite a few different lessons in the design process. If we started again from scratch, there are several things we would have done differently. However, since we were limited on time, we decided to make the best that we could out of the project we set out to create. I believe we were able to accomplish this with a few minor setbacks. Those setbacks will be outlined in section 5 below.

5.0 Project Implementation and Operation

The implementation of the project was done in many different steps to limit the number of errors and be more efficient. The careful implementation of the different components were tested and retested to ensure success. The results and suggested changes are discussed later in this section.

5.1 Details of Implementation

The project was separated into different sections of code depending on the hardware used. Similar hardware was coded in the same section to eliminate many sections and simplify the project. The four sections that we used were GUI, control coding, proxy reader coding, and camera coding. The GUI code included the interface for the user to work with. The control coding included the USB relay that opens the locks and checks the door status. The proxy reader coding included the RFID scanners and the keypad to allow access. The camera coding included the webcams used to snap pictures of those that entered certain levels of security.

The different sections of code were written, tested, and retested separately to limit the number of errors when implemented with the other sections. The sections that were combined together first were the GUI and the control coding. These were worked on first and implementing them was of ease because of the amount of testing and troubleshooting that was done. The proxy reader coding was then implemented, it was a little more difficult troubleshooting and debugging. The three sections combined were tested and debugged to eliminate all the errors and glitches in the system. The camera

coding was the most difficult to implement because of the number of errors encountered. USB cameras were not as easy to incorporate because it was very hard to switch between cameras in the code when needed.

5.2 Operational Test Results

The testing of the system was done throughout the coding and combining of code to simplify the project. After combining the code and setting up the different doors with the security measures in place the program was executed. We found the system ran as expected minus a few glitches that were easily fixed. The most difficult part of the system was the webcams.

The RFID scanners worked as expected, upon a badge scan it would check a text file for that badge to ensure it had clearance and it would log into a text file the time, date, and badge number. If the badge had clearance it opened the door and started a timer to limit the amount of time the door was opened.

The second level of security had the webcam integrated on it and every time a badge was scanned a picture was taken and saved in a file with the time and date.

On the third level of security when the badge was scanned it checked a file to ensure clearance if the badge was cleared it waited for a key code to be entered. Upon a correct key code with the proper badge the door would open starting a timer. The USB relay used would check the status of the switches on the doors to ensure they are closed when needed. When a door was open for too long or opened without permission the alarm would sound and text

messages were sent to individuals designated by the owner. The system had met criteria specified before.

5.3 What Improvements are Suggested by the Design Results

The changes that would be suggested and considered in doing this project again would be the design and types of webcam. The design would be different by using microcontrollers at each door instead of one computer controlling many doors. The design change would simplify the project and make it more efficient in adding new modules to the system. It would make it easier to add things to existing doors as well. The webcams would be changed to IP (Internet Protocol) cameras to simplify the coding a lot and make it work more effectively. The IP cameras would make it easier to switch between cameras, be more secure, and have better resolution.

6.0 Final Scope of Work Statement

The project is near completion and meets most of the requirements specified. The original timeline had to be modified to include the testing times but it did not set us back. The reason it is not complete is the complexity of the webcams discussed later in this section.

6.1 Summary of Completed Work

The criteria for the project have been completed. There are three levels of security the first having just a RFID scanner, the second RFID scanner and camera, and the third level RFID scanner, camera, and keypad. The doors are being monitored all the time to make sure no unauthorized entries occur. There are timers on the doors so they are not opened for more than 10 seconds. The keypad on level three is only activated after a valid badge scan and it allows for five seconds for a code to be entered. The alarm sounds when the door is opened without authorization or the door is opened for more than 10 seconds.

6.2 Summary of Additional Work

The task that has not yet been completed is the camera code. The cameras have been the hardest to code. We still need to figure out how to change between cameras in the code, snap a picture and load the picture to a file.

6.3 Lessons learned

The project has been a great opportunity to learn and grow. There have been many valuable lessons learned throughout the whole process. Selecting

the hardware for this project was a great lesson. It is always great to do extensive research on a piece of hardware and its limitations before moving forward. The hardware that we found and researched was all USB compatible so we use the USB to support our program. This was found to be harder and more complicated than having microcontrollers at each door and talking through IP.

The initial USB hub purchased was thought to have been a powered hub and capable of operating all the components needed. After receiving the hub, that was not powered, and connecting it to the components and central computer it would disconnect different components at different times. The second USB hub we purchased was a powered hub and it ran all the components needed very well.

6.4 Related project management issues

The project management was very good. We accomplished our goals in a timely manner and as expected. One item that was addressed after the first timeline that was made was the testing time. The time allotted for testing was not on the timeline so it needed to be added in. It worked out great because it did not slow down the progress of the project with being able to test the code while still writing new code. This was accomplished because of a multiple person team. The webcam code has taken longer than expected because of the complexity of the code, but hopefully will be completed before the final project. The rest of the project went smoothly and followed the timeline as expected.

7.0 Other Issues

This section of the document covers the materials we chose to use, who we obtained them from, and the overall impact of our project.

7.1 Material Selection

The following table provides a materials list and their associated supplier.

Table 1 - Part Suppliers

Material	Supplier
RF ID Scanners and Badges (3)	Robot Shop Inc.
USB Relay	Spark Fun Electronics
Keypad	Targus through Amazon.com
Limit Switches (3)	USU ECE Store
Camera	ambientweather.com
18 Gauge Wire	Wal-Mart
Doors (3)	Cantwell Bros Lumber Company
Door Knobs (3)	Wal-Mart
USB Hub	Best Buy
USB Extension Cable	Amazon.com
Alarm	Amazon.com
Door Strikes (3)	Discount Home Automation
9V, 2A Power Supply	Deseret Industries
Wire Nuts (26)	USU ECE Store

7.3 Safety

The only safety issue that we came across was during the wiring of all the components. Upon installation, a licensed electrician should be consulted.

7.4 Societal Impact

Allowing a business owner to be in complete control of their security will bring peace of mind to that individual. Using a contracted company to watch your security system can be unnerving because you never know how many people have access to your information and the threat of theft is always constant.

7.5 Maintenance

Maintenance of this system will be relatively low. The USB relay has no mechanical devices controlling the switches, thus making it extremely low maintenance. The electromagnetic locks also will require very little maintenance. The only component that would require regular maintenance is the limit switch. Extensive use of the switches will result in failure to achieve a proper connection. However, if we were to go commercial with this product, we would upgrade to a magnetic sensor bar instead because of the little maintenance needed for those.

7.6 Contracts and Other Legal/Ethical Issues

If we were to go commercial with this product, we would need to obtain rights to licensing from Phidgets, the manufacturer of the RF ID scanners, for the software libraries that we used for the GUI.

7.7 Customer Support and Training

Upon installation of the security system, we would send a well trained associate to install the software on the business's computer and train the business owner how to use the program. We would also offer additional assistance and training during regular business hours by telephone or by an appointment. Customer satisfaction is guaranteed.

7.8 Product Documentation

The security system would come with an executable CD that would download all the programming on the customer's computer. A user manual would also be developed and included with the purchase of the security system.

8.0 Cost Estimations

The following section will cover the cost estimates of the entire project. This would include all of the parts, in addition to any materials needed to create a demonstration model.

8.1 Estimate of System Costs

The following table shows the complete materials list with the associated cost.

Table 2 - Project Cost

Material	Cost
RF ID Scanners and Badges (3)	$210
USB Relay	$67.53
Keypad	$7.63
Limit Switches (3)	$7.00
Camera	$55.14
18 Gauge Wire	$10.00
Doors (3)	$138.98
Door Knobs (3)	$30.00
USB Hub	$13.00
USB Extension Cable	$2.65
Alarm	$19.75
Door Strikes (3)	$77.42
9V, 2A Power Supply	$1.00
Wire Nuts (26)	$2.80
Construction Materials	$5.00
Total	$647.90

The estimated budget for this project was estimated to be about $600. We met the budget with the actual cost of all the parts, but failed to take into account the shipping of the components. Because of shipping costs, we ended up going a little over our estimated budget.

8.2 Estimate of Design Cost

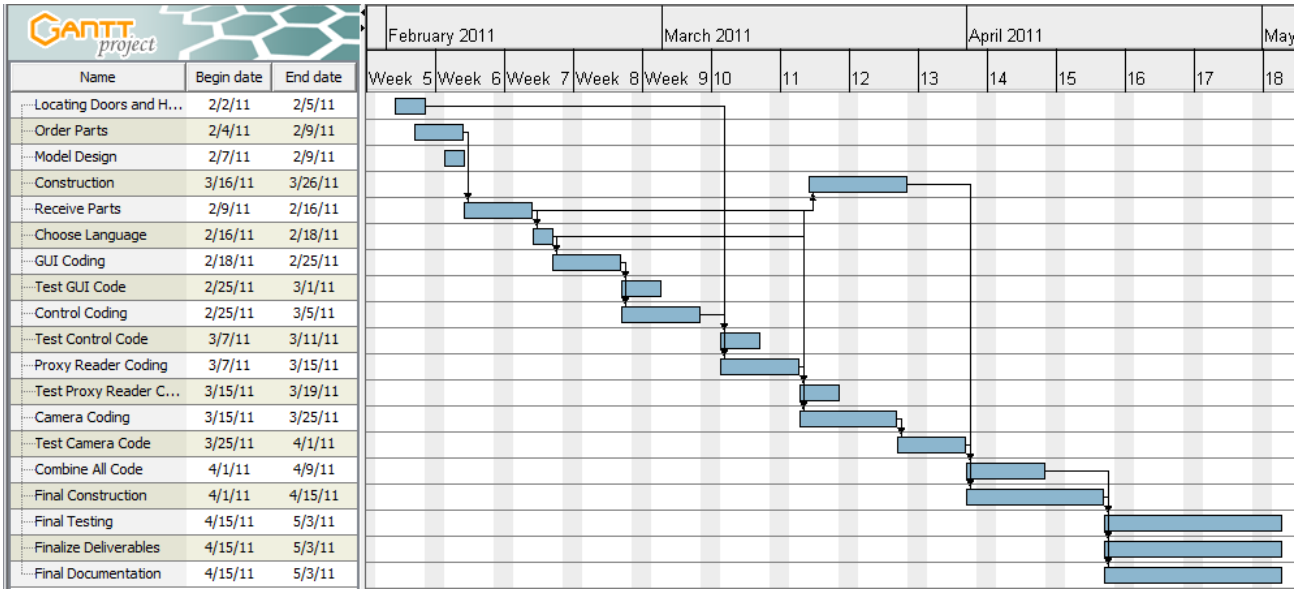
The design of the project was split into two parts: software development and hardware construction. The majority of the time spent on the project was in the software development. Parts of the coding were more difficult than originally anticipated. Hardware construction was fairly straightforward. The development of the entire project took approximately 800 total man-hours to complete.

9.0 Project Management Summary

The project followed the timeline closely after we had made the changes to accommodate for the testing time. The main problem we had during this project was the webcam coding. Webcams took a lot longer to code and figure out than expected so we combined all the code we had other than the webcams and tested it. The program runs great and does all that is required from the beginning.

9.1 Time: Activities, Duration, and Order

In this section we will display the Gantt chart and briefly discuss the activities, duration and order. Although most of this information was covered in Sections 6.1 and Section 6.2 we will discuss some of the points in more detail. Figure 12 below shows the Gantt chart that was followed throughout the project to keep us on track.



Name	Begin date	End date
Locating Doors and H...	2/2/11	2/5/11
Order Parts	2/4/11	2/9/11
Model Design	2/7/11	2/9/11
Construction	3/16/11	3/26/11
Receive Parts	2/9/11	2/16/11
Choose Language	2/16/11	2/18/11
GUI Coding	2/18/11	2/25/11
Test GUI Code	2/25/11	3/1/11
Control Coding	2/25/11	3/5/11
Test Control Code	3/7/11	3/11/11
Proxy Reader Coding	3/7/11	3/15/11
Test Proxy Reader C...	3/15/11	3/19/11
Camera Coding	3/15/11	3/25/11
Test Camera Code	3/25/11	4/1/11
Combine All Code	4/1/11	4/9/11
Final Construction	4/1/11	4/15/11
Final Testing	4/15/11	5/3/11
Finalize Deliverables	4/15/11	5/3/11
Final Documentation	4/15/11	5/3/11

Figure 12 - Gantt Chart

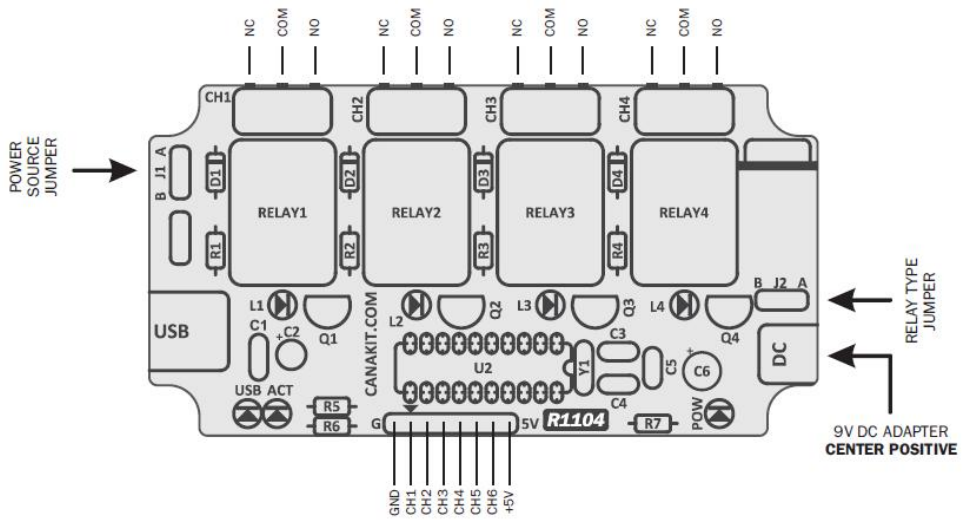
Most of these tasks were handled as a group. However, each of these tasks had an individual in charge of coordinating the work for that section. The GUI and coding was handled by Daniel Kunz. The construction was handled by Michael Engh. The ordering of parts and research of web cameras was handled by Curtis Ostrander. The final construction and testing was handled by Jared Jeppsen. Although the project is mostly complete at this point, we did fall slightly behind due to the complexities of programming a web camera. We still need to finalize the code for this device, as well as do a thorough testing of the complete environment as a working user interface.

10.0 Conclusion

In conclusion, our project had the focus of creating a small business security system that could be utilized by the owner, without incurring the monthly subscription fees associated with security systems. We were able to accomplish this by basing the design around an interface that would be used on the business's computer.

Although we were able to complete our project and produce a deliverable, the lessons we learned throughout the design process will help us refine our design into a more marketable product. Tools such as the Gantt chart were crucial in helping manage our time and meet our deadlines. Even though it took the entire semester to finish the project, the Gantt chart allowed us to more evenly spread our time so the final product was higher quality and not rushed towards the end of the semester.

Appendix A – Canakit UK1104 Specifications



TECHNICAL SPECIFICATIONS

Supported Operating Systems	: Microsoft Windows 2000 / XP / 2003 / 7 Any Operating System supporting USB CDC Virtual COM Ports (e.g. Linux, Mac OS X, etc.)
Number of Relays	: 4
Relay Rating	: 5A 110V AC / 24V DC (Resistive Loads)
Number of I/O Channels	: 6
I/O Channel Modes	: Digital Output Digital Input (TTL/ST)* Analog Input Temperature Sensor
Supported Temp. Sensors	: Maxim/Dallas DS18 Series
Max. Current per I/O Channel	: 25 mA
Max. Total Current for I/O Channels	: 75 mA (45 mA if all Relays are ON)
Max. # of Temperature Sensors	: 6
A/D Conversion Resolution	: 10-bit (5V DC Scale)
Max. Recommended Impedance for Analog Sources	: 10K Ohm
Supply Voltage	
Controller Circuit	: USB powered**
Relay Circuit	: 9V DC ***

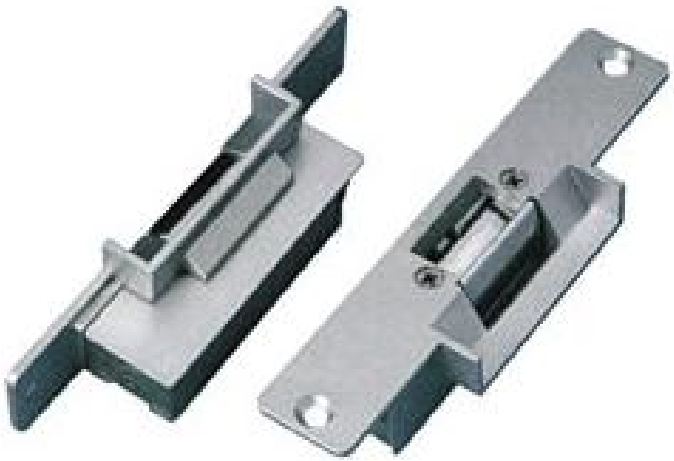
http://www.canakit.com/Media/Manuals/UK1104.pdf

Appendix B – Phidget RFID Specifications

Characteristic	Value
Antenna Output Power (max, far field)	< 10µW
Antenna Resonant Frequency	125kHz – 140kHz
Communication Protocol	EM4102
Read Update Rate	30 updates / second
External +5V Supply Voltage	5VDC
External +5V Supply Current Limit	400mA
External LED Supply Voltage	5VDC
External LED Supply Current Limit	16mA
External LED Output Resistance	250 Ohms
Recommended Terminal Wire Size	16 – 26 AWG
Terminal Wire Strip Length	5 – 6mm (0.196" – 0.236")
USB-Power Current Specification	500mA max
Device Quiescent Current Consumption	16mA
Device Active Current Consumption	100mA max
Typical Read Distance – Credit Card Tag	11cm (5")
Typical Read Distance – Disk Tag	6cm (3")
Typical Read Distance – Key Fob Tag	7cm (3.5")
Operating Temperature	0 - 70°C

http://www.phidgets.com/products.php?category=14&product_id=1023

Appendix C – SECO-LARM SK-990AQ Specifications



	SK-990AQ	SK-990BQ
Type	Fail Secure	Fail Safe
Circuit Type	N.O.	N.C.
Input Voltage	10~14VDC	10~14VDC
Current	450mA	200mA
Coil Resistance	26Ω	60Ω
Polarity	None	None
Weight	350g	350g

http://www.seco-larm.com/SK990b.htm